BELLCOMM, INC.
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B70 12065

SUBJECT: Optimization of Launch Azimuth Range to Adjust Launch Window Duration And Improve Launch Vehicle Performance Margin - Case 310

DATE: December 23, 1970

FROM: S. F. Caldwell
K. E. Martersteck

MEMORANDUM FOR FILE

[redacted]

In reviewing the launch opportunities for the J missions, it was noted that in some months the launch window is barely two hours in duration. Examination of the relationship between launch window duration and the other launch parameters revealed the possibility of extending the launch window duration in cases where it is short while also increasing the launch vehicle performance margins for all launches. This is accomplished by adjusting the range of allowable launch azimuths as outlined below.

The launch window duration is a nonlinear function of launch azimuth and in general asymmetrical with respect to 90° (Figures 1-4). In particular, for summer launches (to Hadley and Copernicus or Marius Hills) and an azimuth range of 72°-96°, the window durations are typically about 2-1/2 hours with the shortest being 2:08 (Table I). Because of the steepness of the window duration vs. azimuth curve near 90°, a relatively large amount of time can be added to the window by extending the azimuth range a few degrees beyond 96°.

The current launch vehicle baseline performance is established for a 72° launch azimuth, which is the worst case for the performance over the presently allocated azimuth range of 72°-96°. However, as shown in Figure 5, the closer the launch azimuth is to 90°, the greater is the launch vehicle payload capability, since the earth's rotation makes a greater velocity contribution thereby reducing the launch to earth orbit energy requirement of the vehicle. Ideally, the range of azimuths should be symmetrical about and close to 90° for maximum launch vehicle performance margin.

By taking advantage of the nonlinearity in the duration vs. azimuth relation on missions such as Apollo 15 to Hadley, the lower limit of the azimuth range can be increased about twice as much as the upper limit is raised, thereby eliminating most of the opportunity-to-opportunity variation in window duration. In other words, the shortest windows are extended while the longer windows become shorter. Because this shift in the azimuths raises the minimum azimuth, the payload capability is also increased proportionally. Table I gives examples of two cases: an azimuth range of 80°-100° and one of 82°-100°. The 80°-100° limits give a very uniform launch window duration of 2:44 ± 3 min. for all opportunities considered and an increase in payload margin of 570 lbs. Using the 82°-100° range would give windows from 2:20 to 2:42 and a payload gain of 660 lbs.

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Tracking requirements may rule out the use of azimuths beyond 100° because of coverage available from Bermuda during launch. A preliminary look at the tracking coverage indicated that some difficiencies do exist for a second injection opportunity following a launch near 100°. However, the differences in tracking coverage between a 96° launch and a 100° launch appear to be slight.

Because of the potential for extending durations of the short windows as well as improving the launch vehicle payload capability for all opportunities, apparently achievable with little operational degradation, serious consideration should be given to optimizing the launch azimuth limits for the J missions.

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Attachments

TABLE I

LAUNCH WINDOW DURATION FOR VARIOUS LAUNCH AZIMUTH RANGES

Site	Launch Time	Launch Window Duration (Hours:Minutes) For a Launch Azimuth Range Of		
		72°-96°	80°-100°	82°-100°
Hadley	7/26/71	2:44	2:41	2:29
	8/24/71	2:26	2:43	2:33
	9/23/71	2:08	2:47	2:42
	10/22/71	2:24	2:42	2:33
Descartes	1/18/72	3:19	2:41	2:24
	2/17/72	3:42	2:42	2:21
	3/17/72	4:12	2:46	2:20
Marius Hills	6/19/72	2:50	2:42	2:33
	7/19/72	2:32	2:42	2:35
	8/17/72	2:13	2:41	2:32
Copernicus	6/16/72	2:23	2:42	2:29
	7/16/72	2:10	2:41	2:31
	8/14/72	2:29	2:42	2:35
PAYLOAD GAIN		0 lbs.	570 lbs.	660 lbs.

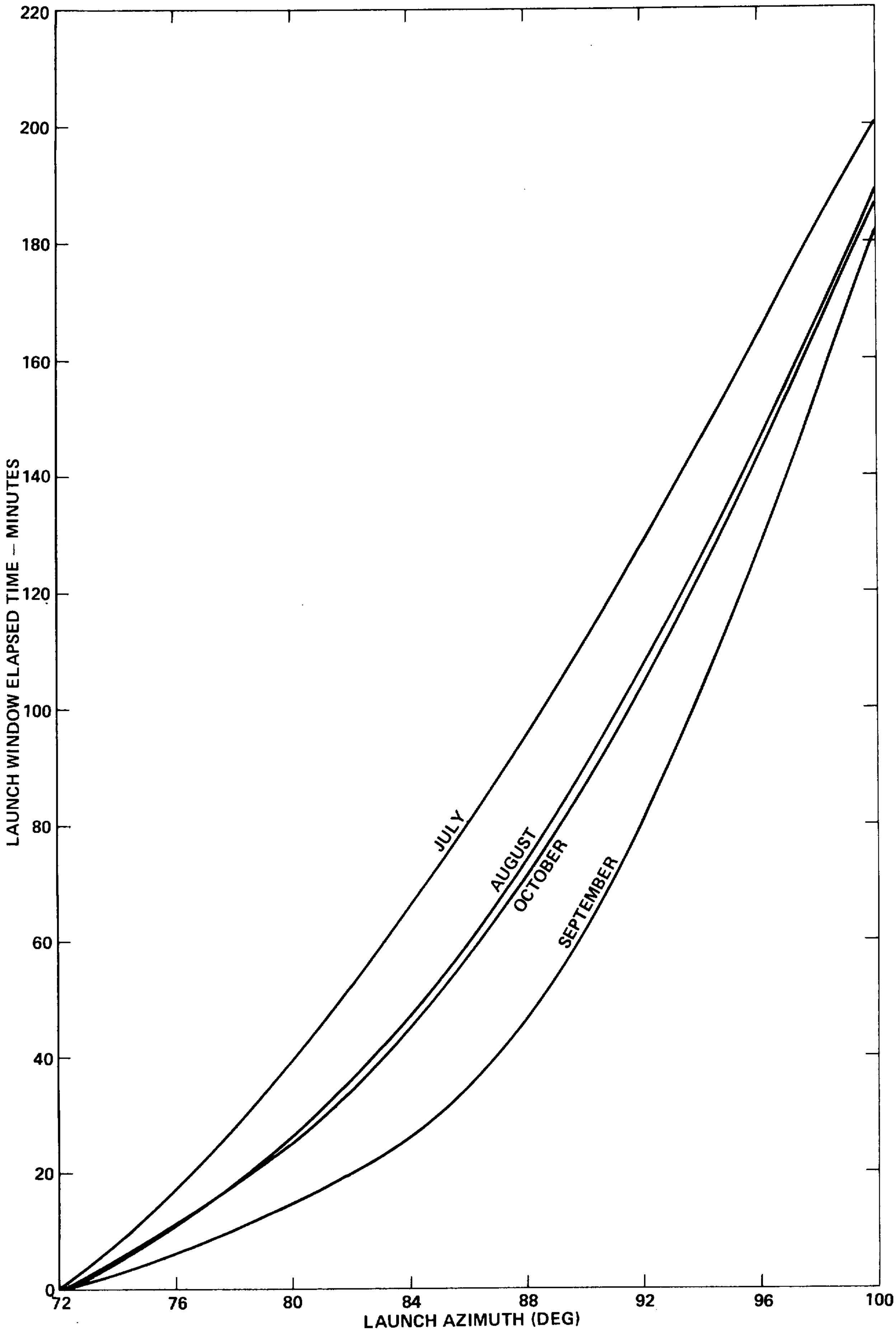

FIGURE 1 - HADLEY

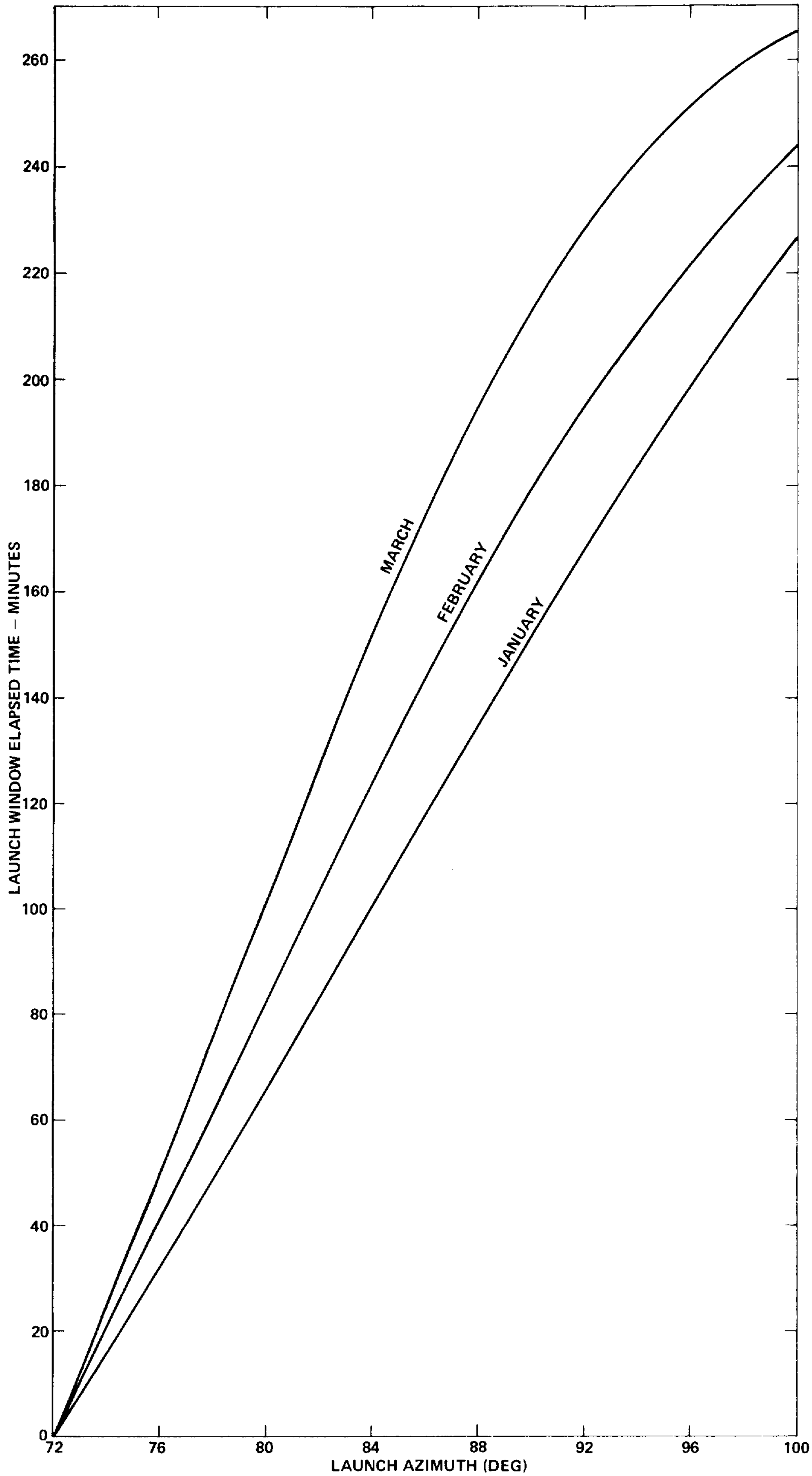

FIGURE 2 - DESCARTES

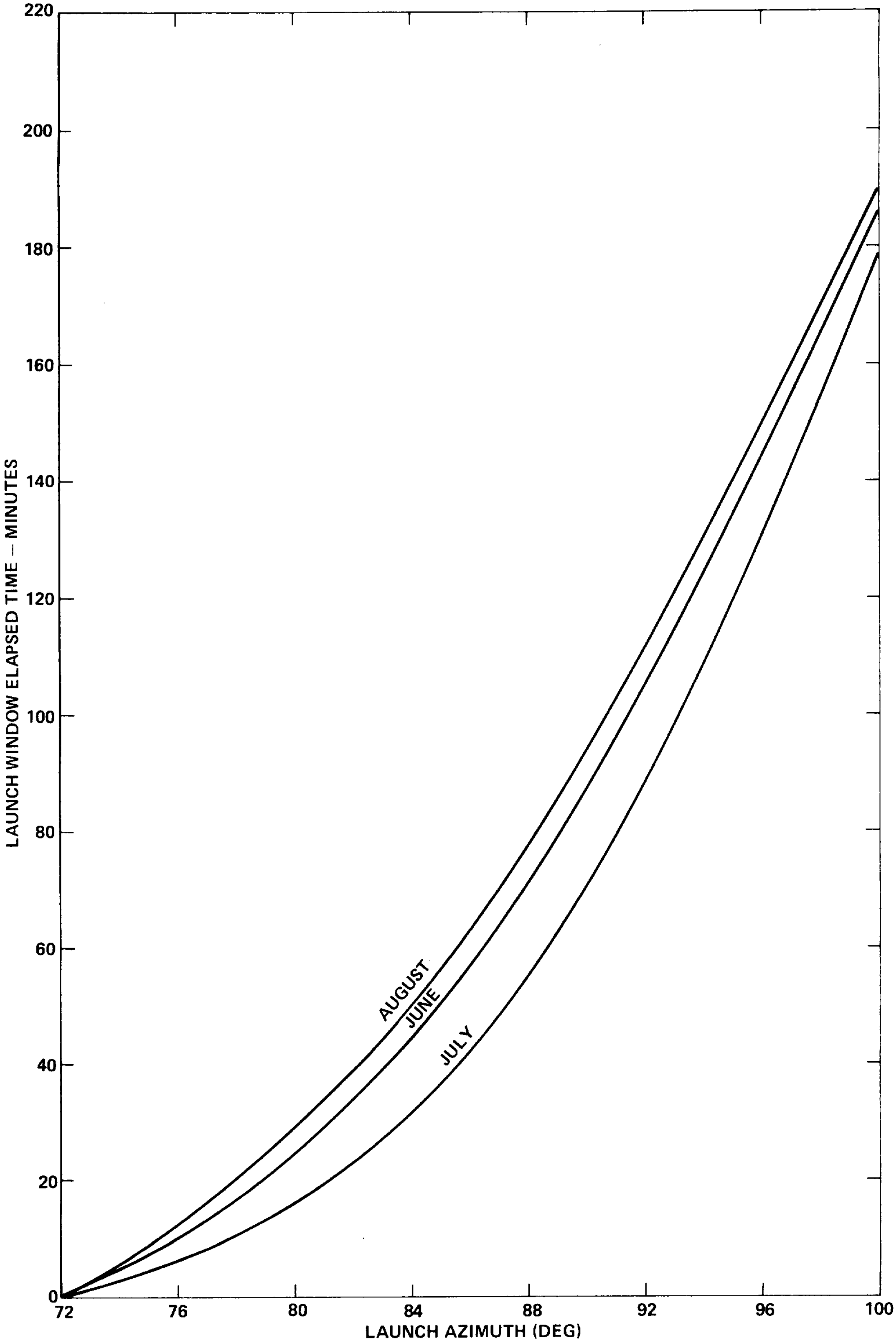

FIGURE 3 - MARIUS HILLS

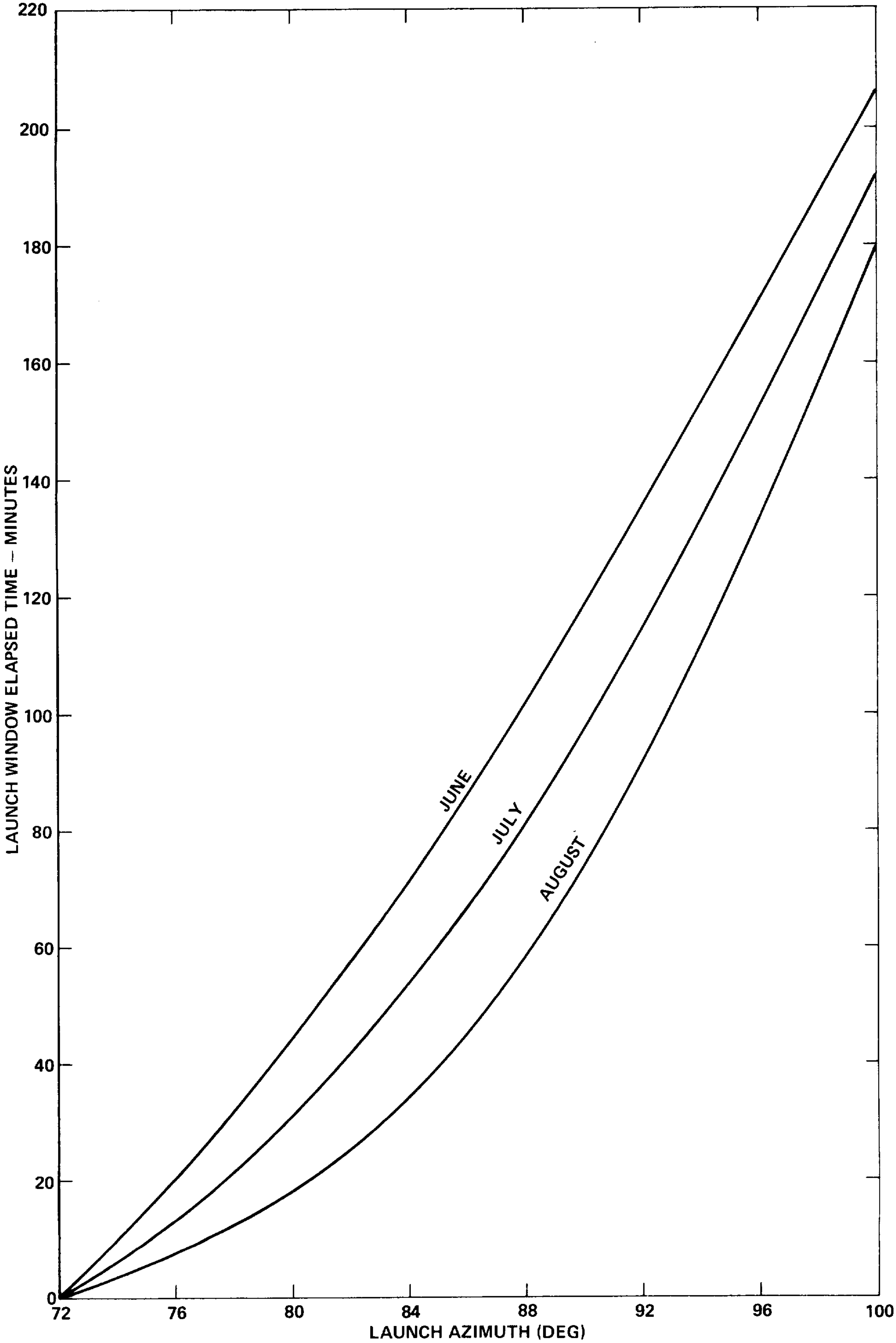

FIGURE 4 - COPERNICUS

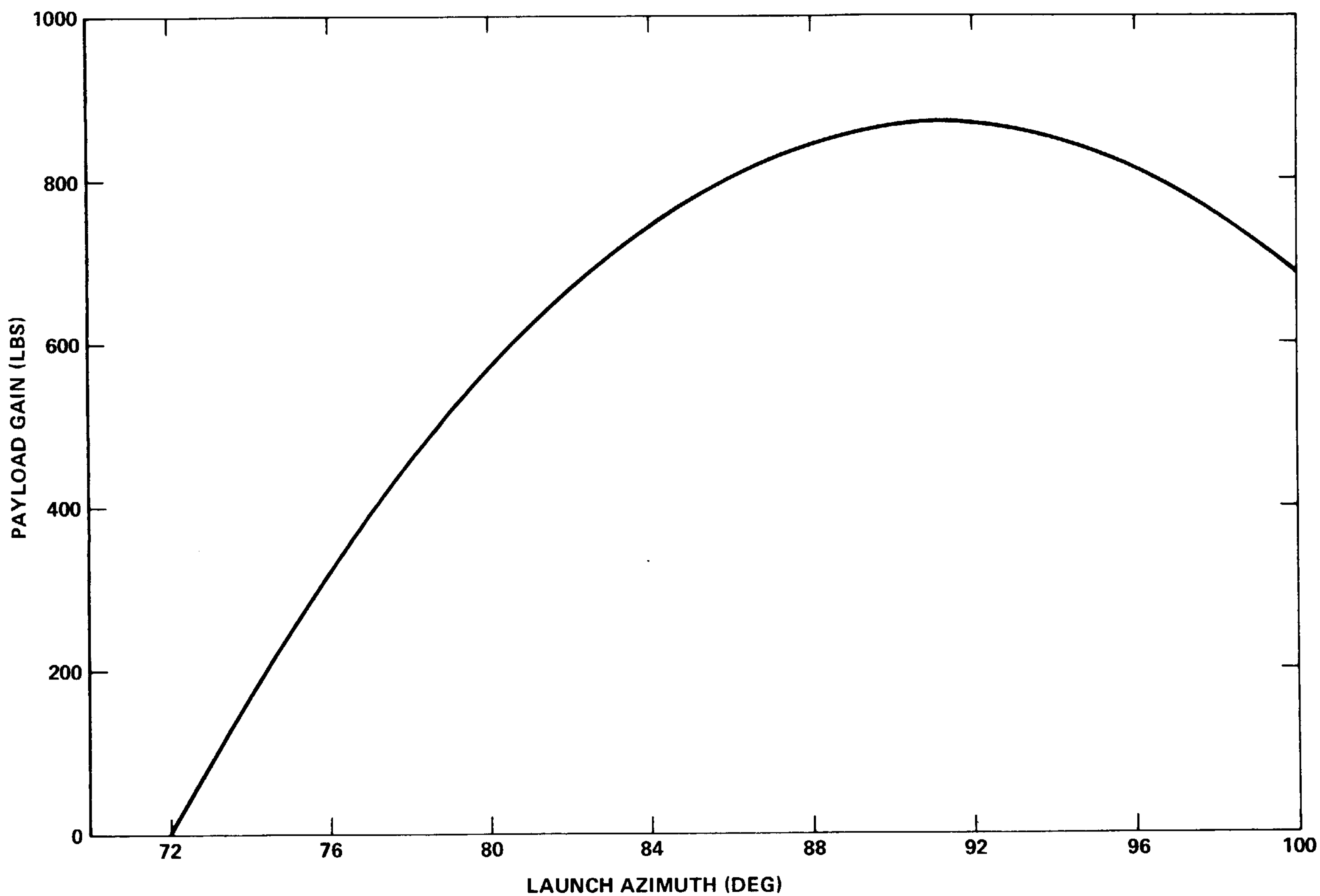

FIGURE 5 - LAUNCH VEHICLE PAYLOAD GAIN FOR VARIOUS LAUNCH AZIMUTHS

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